

WHAT IS CLAIMED IS:

1           1.       A method for managing a network providing Input/Output (I/O) paths  
2 between a plurality of host systems and storage volumes in storage systems,  
3 comprising:  
4           providing an application service connection definition for each connection  
5 from a host to a storage volume;  
6           providing at least one service level guarantee definition indicating  
7 performance criteria to satisfy service requirements included in at least one service  
8 level agreement with at least one customer for network resources;  
9           associating each service level guarantee definition with at least one  
10 application service connection definition; and  
11           monitoring whether Input/Output (I/O) requests transmitted through the  
12 multiple I/O paths satisfy performance criteria indicated in the service level guarantee  
13 definition associated with the I/O paths.

1           2.       The method of claim 1, wherein each service level guarantee definition  
2 is implemented as a separate element in at least one Extended Markup Language  
3 (XML) document, the element for the service level guarantee includes the  
4 performance criteria defined in the service level agreement, and wherein the  
5 application service connection definition for each connection is implemented as an  
6 element in a at least one XML document, wherein the attributes of the application  
7 service connection element provide information on the connection.

1           3.       The method of claim 1, wherein multiple service level guarantee  
2 definitions indicating different performance criteria are associated with different sets  
3 of application service connection definitions.

1           4.       The method of claim 3, wherein the application service definition for  
2 one connection may be associated with multiple service level guarantee definitions,

3 wherein the monitoring comprises determining whether I/O requests transmitted  
4 through one connection satisfy the performance criteria of all associated service level  
5 guarantee definitions.

1           5.       The method of claim 1, further comprising:  
2           providing an application service group identifying a plurality of application  
3 service connection definitions, wherein associating the service level guarantee  
4 definition with the application service connection definitions comprises associating  
5 each service level guarantee definitions with at least one application service group,  
6 wherein the application service connection definitions identified in the application  
7 service group are associated with the service level guarantee definitions with which  
8 their application service group is associated.

1           6.       The method of claim 5, further comprising:  
2           providing a service level commitment record associating one service level  
3 agreement definition with at least one application service group.

1           7.       The method of claim 5, wherein at least one Extended Markup  
2 Language (XML) document includes one element for each application service group,  
3 and wherein the element for each application service group includes one sub-element  
4 for each application service connection included in that application service group,  
5 wherein each application service connection subelement includes attributes providing  
6 information on the application service connection.

1           8.       The method of claim 1, wherein monitoring whether Input/Output  
2 (I/O) requests transmitted through the multiple I/O paths satisfy performance criteria  
3 indicated in the service level guarantee definition comprises:  
4           gathering performance information concerning I/O requests for each  
5 connection;

6           selecting one service level guarantee definition; and  
7           for each connection identified by one application service connection  
8 definition associated with the selected service level guarantee definition, comparing  
9 the gathered performance information for the connection with the performance  
10 criteria indicated in the selected service level guarantee definition.

1           9.     The method of claim 8, further comprising:  
2           adjusting operations among the I/O paths represented by the application  
3 service connection definitions associated with the selected service level guarantee  
4 definition if the gathered performance information for the I/O paths does not satisfy  
5 the performance criteria.

1           10.    The method of claim 9, wherein adjusting the operations comprises:  
2           determining I/O paths that are over performing and under performing with  
3 respect to the performance criteria; and  
4           throttling the transmission of I/O requests through I/O paths that are over  
5 performing.

1           11.    The method of claim 10, wherein throttling the transmissions  
2 comprises delaying the processing of I/O requests transmitted through the over  
3 performing I/O paths.

1           12.    The method of claim 8, wherein gathering performance information  
2 for I/O paths comprises determining an I/O response time and I/O demand at the I/O  
3 paths and comparing the determined I/O response time and the I/O demand with  
4 performance criteria for response time and demand in the selected service level  
5 guarantee definition.

1           13.    The method of claim 12, wherein I/O demand comprises I/O  
2 operations per second per unit of contracted storage capacity and I/O throughput per  
3 contracted storage capacity.

1           14.    The method of claim 13, wherein a connection is under performing if a  
2 percentage of I/O response times measured for the connection is less than a  
3 percentage guarantee indicated in the selected service level guarantee definition.

1           15.    The method of claim 13, wherein a connection is under performing if  
2 the I/O demand exceeds the demand criteria indicated in the service level guarantee  
3 definition and a sampling of the measured I/O response times is less than the response  
4 time criteria indicated in the service level guarantee definition.

1           16.    The method of claim 1, wherein the I/O paths are monitored by  
2 performance gateways monitoring I/O paths between hosts and storage volumes.

1           17.    The method of claim 16, wherein the network comprises a Storage  
2 Area Network (SAN) and the performance gateways are implemented in a  
3 virtualization controller, and wherein the storage volumes comprise logical volumes  
4 in a virtualization layer implemented in the virtualization controller.

1           18.    The method of claim 1, wherein the application service connections,  
2 service level guarantees, service level guarantee definitions, application service  
3 definitions information, and the monitoring of the I/O requests are provided by a  
4 server in a web service architecture that interfaces with a client to provide real time  
5 performance information on the I/O paths to the client.

1           19.    A system for managing a network providing Input/Output (I/O) paths  
2   between a plurality of host systems and storage volumes in storage systems,  
3   comprising:  
4           a processing unit;  
5           code executed by the processing unit to cause operations to be performed, the  
6   operations comprising:  
7           (i) providing an application service connection definition for each  
8       connection from a host to a storage volume;  
9           (ii) providing at least one service level guarantee definition indicating  
10      performance criteria to satisfy service requirements included in at least one  
11      service level agreement with at least one customer for network resources;  
12           (iii) associating each service level guarantee definition with at least  
13      one application service connection definition; and  
14           (iv) monitoring whether Input/Output (I/O) requests transmitted  
15      through the multiple I/O paths satisfy performance criteria indicated in the  
16      service level guarantee definition associated with the I/O paths.

1           20.    The system of claim 19, further comprising:  
2       a storage medium including at least one Extended Markup Language (XML)  
3   document having:  
4           (i) a separate element for each service level guarantee definition,  
5       wherein the element for the service level guarantee includes the performance  
6       criteria defined in the service level agreement; and  
7           (ii) a separate element for each application service connection  
8       definition for each, wherein the attributes of the application service  
9       connection element provide information on the connection.

1           21.     The system of claim 19, wherein multiple service level guarantee  
2 definitions indicating different performance criteria are associated with different sets  
3 of application service connection definitions.

1           22.     The system of claim 21, wherein the application service definition for  
2 one connection may be associated with multiple service level guarantee definitions,  
3 wherein the monitoring comprises determining whether I/O requests transmitted  
4 through one connection satisfy the performance criteria of all associated service level  
5 guarantee definitions.

1           23.     The system of claim 19, wherein the operations further comprise:  
2           providing an application service group identifying a plurality of application  
3 service connection definitions, wherein associating the service level guarantee  
4 definition with the application service connection definitions comprises associating  
5 each service level guarantee definitions with at least one application service group,  
6 wherein the application service connection definitions identified in the application  
7 service group are associated with the service level guarantee definitions with which  
8 their application service group is associated.

1           24.     The method of claim 23, further comprising:  
2           a storage medium having at least one Extended Markup Language (XML)  
3 document that includes one element for each application service group, and wherein  
4 the element for each application service group includes one sub-element for each  
5 application service connection included in that application service group, wherein  
6 each application service connection subelement includes attributes providing  
7 information on the application service connection.

1           25.    The system of claim 19, wherein monitoring whether Input/Output  
2 (I/O) requests transmitted through the multiple I/O paths satisfy performance criteria  
3 indicated in the service level guarantee definition comprises:  
4           gathering performance information concerning I/O requests for each  
5 connection;  
6           selecting one service level guarantee definition; and  
7           for each connection identified by one application service connection  
8 definition associated with the selected service level guarantee definition, comparing  
9 the gathered performance information for the connection with the performance  
10 criteria indicated in the selected service level guarantee definition.

1           26.    The system of claim 25, wherein the operations further comprise:  
2           adjusting operations among the I/O paths represented by the application  
3 service connection definitions associated with the selected service level guarantee  
4 definition if the gathered performance information for the I/O paths does not satisfy  
5 the performance criteria.

1           27.    The system of claim 26, wherein adjusting the operations comprises:  
2           determining I/O paths that are over performing and under performing with  
3 respect to the performance criteria; and  
4           throttling the transmission of I/O requests through I/O paths that are over  
5 performing.

1           28.    The system of claim 25, wherein gathering performance information  
2 for I/O paths comprises determining an I/O response time and I/O demand at the I/O  
3 paths and comparing the determined I/O response time and the I/O demand with  
4 performance criteria for response time and demand in the selected service level  
5 guarantee definition.

1           29.    The system of claim 19, further comprising:  
2           performance gateways to monitor the I/O paths between hosts and storage  
3           volumes.

1           30.    The system of claim 19, wherein the processing unit comprises a  
2           server in a web service architecture that interfaces with a client to provide real time  
3           performance information on the I/O paths to the client.

1           31.    An article of manufacture for managing a network providing  
2           Input/Output (I/O) paths between a plurality of host systems and storage volumes in  
3           storage systems, wherein the article of manufacture causes operations to be  
4           performed, the operations comprising:  
5           providing an application service connection definition for each connection  
6           from a host to a storage volume;  
7           providing at least one service level guarantee definition indicating  
8           performance criteria to satisfy service requirements included in at least one service  
9           level agreement with at least one customer for network resources;  
10          associating each service level guarantee definition with at least one  
11          application service connection definition; and  
12          monitoring whether Input/Output (I/O) requests transmitted through the  
13          multiple I/O paths satisfy performance criteria indicated in the service level guarantee  
14          definition associated with the I/O paths.

1           32.    The article of manufacture of claim 31, wherein each service level  
2           guarantee definition is implemented as a separate element in at least one Extended  
3           Markup Language (XML) document, the element for the service level guarantee  
4           includes the performance criteria defined in the service level agreement, and wherein  
5           the application service connection definition for each connection is implemented as



6 an element in a at least one XML document, wherein the attributes of the application  
7 service connection element provide information on the connection.

1 33. The article of manufacture of claim 31, wherein multiple service level  
2 guarantee definitions indicating different performance criteria are associated with  
3 different sets of application service connection definitions.

1 34. The article of manufacture of claim 33, wherein the application service  
2 definition for one connection may be associated with multiple service level guarantee  
3 definitions, wherein the monitoring comprises determining whether I/O requests  
4 transmitted through one connection satisfy the performance criteria of all associated  
5 service level guarantee definitions.

1 35. The article of manufacture of claim 31, wherein the operations further  
2 comprise:  
3 providing an application service group identifying a plurality of application  
4 service connection definitions, wherein associating the service level guarantee  
5 definition with the application service connection definitions comprises associating  
6 each service level guarantee definitions with at least one application service group,  
7 wherein the application service connection definitions identified in the application  
8 service group are associated with the service level guarantee definitions with which  
9 their application service group is associated.

1 36. The article of manufacture of claim 35, wherein at least one Extended  
2 Markup Language (XML) document includes one element for each application  
3 service group, and wherein the element for each application service group includes  
4 one sub-element for each application service connection included in that application  
5 service group, wherein each application service connection subelement includes  
6 attributes providing information on the application service connection.

1           37.     The article of manufacture of claim 36, wherein the operations further  
2 comprise:  
3           providing a service level commitment record associating one service level  
4 agreement definition with at least one application service group.

1           38.     The article of manufacture of claim 31, wherein monitoring whether  
2 Input/Output (I/O) requests transmitted through the multiple I/O paths satisfy  
3 performance criteria indicated in the service level guarantee definition comprises:  
4           gathering performance information concerning I/O requests for each  
5 connection;  
6           selecting one service level guarantee definition; and  
7           for each connection identified by one application service connection  
8 definition associated with the selected service level guarantee definition, comparing  
9 the gathered performance information for the connection with the performance  
10 criteria indicated in the selected service level guarantee definition.

1           39.     The article of manufacture of claim 38, wherein the operations further  
2 comprise:  
3           adjusting operations among the I/O paths represented by the application  
4 service connection definitions associated with the selected service level guarantee  
5 definition if the gathered performance information for the I/O paths does not satisfy  
6 the performance criteria.

1           40.     The article of manufacture of claim 39, wherein adjusting the  
2 operations comprises:  
3           determining I/O paths that are over performing and under performing with  
4 respect to the performance criteria; and  
5           throttling the transmission of I/O requests through I/O paths that are over  
6 performing.

1           41.     The article of manufacture of claim 40, wherein throttling the  
2     transmissions comprises delaying the processing of I/O requests transmitted through  
3     the over performing I/O paths.

1           42.     The article of manufacture of claim 38, wherein gathering performance  
2     information for I/O paths comprises determining an I/O response time and I/O  
3     demand at the I/O paths and comparing the determined I/O response time and the I/O  
4     demand with performance criteria for response time and demand in the selected  
5     service level guarantee definition.

1           43.     The article of manufacture of claim 42, wherein I/O demand comprises  
2     I/O operations per second per unit of contracted storage capacity and I/O throughput  
3     per contracted storage capacity.

1           44.     The article of manufacture of claim 43, wherein a connection is under  
2     performing if a percentage of I/O response times measured for the connection is less  
3     than a percentage guarantee indicated in the selected service level guarantee  
4     definition.

1           45.     The article of manufacture of claim 43, wherein a connection is under  
2     performing if the I/O demand exceeds the demand criteria indicated in the service  
3     level guarantee definition and a sampling of the measured I/O response times is less  
4     than the response time criteria indicated in the service level guarantee definition.

1           46.     The article of manufacture of claim 31, wherein the application service  
2     connections, service level guarantees, service level guarantee definitions, application  
3     service definitions information, and the monitoring of the I/O requests are provided  
4     by a server in a web service architecture that interfaces with a client to provide real  
5     time performance information on the I/O paths to the client.

1           47.     A system for managing a network providing Input/Output (I/O) paths  
2     between a plurality of host systems and storage volumes in storage systems,  
3     comprising:  
4           means for providing an application service connection definition for each  
5     connection from a host to a storage volume;  
6           means for providing at least one service level guarantee definition indicating  
7     performance criteria to satisfy service requirements included in at least one service  
8     level agreement with at least one customer for network resources;  
9           means for associating each service level guarantee definition with at least one  
10    application service connection definition; and  
11          means for monitoring whether Input/Output (I/O) requests transmitted through  
12    the multiple I/O paths satisfy performance criteria indicated in the service level  
13    guarantee definition associated with the I/O paths.

1           48.     The system of claim 47, wherein multiple service level guarantee  
2     definitions indicating different performance criteria are associated with different sets  
3     of application service connection definitions.

1           49.     The system of claim 47, further comprising:  
2           means for providing an application service group identifying a plurality of  
3     application service connection definitions, wherein associating the service level  
4     guarantee definition with the application service connection definitions comprises  
5     associating each service level guarantee definitions with at least one application  
6     service group, wherein the application service connection definitions identified in the  
7     application service group are associated with the service level guarantee definitions  
8     with which their application service group is associated.